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ABSTRACT

In response to a serious shortage of chemists in South Africa, gifted secondary school students are enrolled in an enrichment program in organic chemistry and encouraged to consider chemistry or one of its related fields as a career. The introductory portion of the program involves approximately 90 hours over a 3-year period while the advanced portion takes 120-160 hours over 3 years. Students are introduced to the chemical industry, the methods and instruments it uses, and the products it manufacturers. They are made acquainted with basic techniques through experiments. The course outline includes the following topics: (1) an introduction to organic chemistry; (2) human chemical intervention; (3) the alkanes, alkynes, halo-alkanes, alcohols-alkanols, alkanals and alkanones, and alkanoic acids and derivatives; (4) drugs; (5) polymers; (6) South African chemical industry; (7) chemistry and agriculture; (8) chemistry for fire technology; (9) chemical explosives; and (10) practical work (e.g., chemiluminescence, distillation, fractional distillation, fermentation). Future plans include enhancement of the computer instruction component, improving opportunities for visiting industrial sites, and encouraging students to publish. (VW)

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TITLE PAGE

Organic Chemistry for the gifted

by

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Subject category:-

Neither this paper nor any version close to it has been, or is being, offered for publication. The paper will be presented orally at Ingenium 2000 by the author.

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ABSTRACT

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1. Introduction

Although the title of this talk refers to Organic Chemistry, it may be regarded as valid to almost all the different branches of chemistry.

What are we trying to achieve? In South Africa there is a chronic shortage of natural scientists, especially chemists. In this course we try to get the gifted scholar interested in chemistry. First in the subject itself and then in considering chemistry, or one of its related fields as a possible career.

2. Problems encountered

2.1 Little scientific background

As was mentioned in the introduction there is a shortage of chemists in the industry. With a present salary problem in secondary education one would expect a serious shortage of qualified, not even to mention experienced science teachers. If one is not fully qualified for the job, and has no interaction with the South African chemical industry, one would consider it to be rather difficult to motivate a scholar to accept chemistry as a possible future career. The result is that most pupils come to the classes for the gifted with little knowledge about what is going on in the South African chemical industry, what job opportunities exist, in short with very little scientific background.

2.2 Scientific instrumentation

Unfortunately most scientific instrumentation is imported. As a result of the unfavourable relation between the Dollar and the Rand; it is rather difficult to supply the necessary instrumentation. This very important branch of chemistry is therefore not given adequate attention. The long lasting recession in our economy is aggravating the situation. A thorough knowledge of instrumentation is so important in the chemical industry.

2.3 Time allocation

At the present moment we have the std 8 pupils for about 60-80 hours per year. In std 9 we have them for about 30-40 hours per year (the rest of the hours going to Geology). In std. 10 the time again spent on chemistry is 30-40 hours per year, because of the record examinations and the early start of the final examinations. So in total we spent approximately 120-160 hours on more advanced Organic Chemistry.
A pupil starting in std 5, gets approximately 90 hours in total for std 5, 6 and 7 on introductory chemistry, like atomic structure the chemical bond, equations, stoichiometry, etc. Not much time to do what you actually want, bearing in mind that 50% of the time is spent on practicals. After all chemistry is an experimental science.

3. The curriculum

3.1 What are we trying to achieve

Although overlapping with the normal school's chemistry curriculum is unavoidable, we try to avoid excessive duplication. We do the basics and then try to do additional work that is not part of the school's curriculum. Our approach further is that we want the pupil to get acquinted with what is going on in the Chemical industry. What are they manufacturing, what methods and instruments are they using in the industry, and what are the products manufactured used for. Then we give them experiments to do in which they can get acquinted with some basic techniques, like distillation, fractional distillation etc.

3.2 Broad outline of the curriculum

3.2.1. Std 8

3.2.1.1 An introduction to Organic Chemistry

- Formules used in Organic chemistry
- Catenation
- Classification of Organic compounds
- Functional groups
- Homologous series
- Activities of the Organic Chemist (Elucidation of structure, synthesis of Organic chemicals, study of reaction mechanisms).
- Structural isomerism
- General types of Organic reactions
- Sources of Organic compounds (coal, crude oil, refineries).

3.2.1.2 Human chemical intervention

- The population curve
- Natural sources and pollution
- Nuclear fusion and fission
- Breeder reactors
- The Greenhouse effect
- Petrochemicals
- The energy crisis
- Energy options (Hydrogen gas, methanol, shale oil, coal, nuclear energy, the sun, Geothermal energy.

3.2.1.3 The alkanes

- Nomenclature
- Methods of preparation
- Chemical reactions
- Industrial important alkanes (methane, ethane,propane)

3.2.1.4 The alkanes

- Nomenclature
- Preparation
- Chemical properties
- Industrial important alkenes (Ethylene, Propere)

3.2.1.5 The alkynes

- Nomenclature
- Preparation of acetylene
- Properties of alkynes
- Industrial uses of acetylene

3.2.1.6 Halo-alkanes

- Nomenclature
- Methods of preparation
- Chemical properties
- Industrial aspects of organo halogens (PVC, neoprene, Teflon, insecticides, solvents, extinguishing agents, refrigerants.

3.2.1.7 Alcohols-Alkanols

- Nomenclature

- Industrial preparation of industriallyimportant alcohols for eg. methanol, ethanol, ethylene glycol glycerol.

- Reactions of the alcohols

- Alcohols in nature-Fragance of fruits, cholesterol, ergosterol (Vit D), Morphine, Quinine.

3.2.1.8 Alkanals and alkanones

- Nomenclature

- Preparation, especially industrially of formaldehyde, asetaldehyde, acetone.

- Chemical properties

- Natural occuring carbonyl compounds, Camphor, citral etc.

3.2.1.9 Alkanoic acids and derivatives

- Nomenclature

- Industrial preparations of formic acid, acetic acid, phthalic acid

- Chemical properties

- Natural occuring acids and esters

- Fats and oils

- Important alkanoic acids, methanoic acid, buturic acid lactic acid, citric acid, nicotinic acid, phenylacetic acid.

3.2.1.10 Practical work

- Chemiluminescence, the light of the firefly

- Elementary distillation, mixture of ether and ethanol

- Fractional distillation

- Decomposition of organic compounds, chemical snakes

- Isolation of eugenol from cloves

3.2.2 Std. 9

3.2.2.1 Drugs

- Classification of drugs
- Drugs affecting the cardiovascular system (Hypertension, angina pectoris, Arrthymia,
- Diuretic drugs
- Drugs affecting the central nerve system,tranquilisers
- Hypnotic drugs, barbiturates
- Stimulants, adrenaline
- Analgesics, plant alkaloids, codein, aspirin, pheracetin, paracetomol
- Drugs against colds and hayfever, antihistamine
- Hallucinating drugs, mirijuana, THC, PCP

3.2.2.2 Polymers

- General properties
- Classification, addition and condensation polymers
- Formation of addition polymers
- Vinylpolymers and their uses
- Atactic, isotactic and syndiotactic polymers
- Condensation polymers, Dacron, terylene, nylon, polyurethanes.
- Diene polymners and synthetic rubber
- Elastomers, plastics, fibres.

3.2.2.3 - S.A. Chemical industry

- Develcpments in the S A Chemical industry
- Fuels, methanol, ethanol
- Polymers
- The S A Chemical industry and agriculture
- Chemistry and manpower
- Careers for the qualified chemist
- The training of chemists
- The present production of the S A Chemical industry.

3.2.2.4 Practicals

- Fermentation, preparation of mampoer
- Preparation of some naturally occuring esters, for eg. butyl acetate present in pineapples.
- A study of photochromic compounds

3.2.3 Std 10 Typical applications

3.2.3.1 Chemistry and agriculture

- Fertilizers
- Insecticides, pesticides, pheromones, hormones

3.2.3.2 Chemistry for Fire Technology

- History
- Hazardous materials
- Cryogenic gasses
- Chemistry of extinquishing fires

3.2.3.3 Chemical explosives

- Properties of explosives
- Ammonium nitrate, uses and properties, effect of heat on ammonium nitrate, case studies, chemical explanations
- Nitroglycerine, dynamite
- Aromatic nitro explosives, TNT
- Cyclonite, RDX
- Tetryl
- PETN
- Picric acid
- Primary explosives
- Gas explosives

3.2.3.4 Practicals

- Isolation of caffein from tea
- Determination of caffein in cola drinks
- A study of thermochromic substances
- A study of mero cyanine dyes

4. Future developments

4.1 Introduction to the computer

To fully appreciate the computer as a study aid one must in the first instance have a working knowledge of the computer including the use of a suitable computer language like Basic

In the second instance one must have a sound knowledge of Chemistry itself in order to write suitable programs. It is therefore critical to judge the right time to introduce the computer.

Another problem at the present moment is that suitable programs are not readily available commercially in South-Africa. Representatives are rather vague about importing programs and the bookshops are usually not interested in supplying such programs.

We intend writing programs and we would like to make contact with other users in order to swop programs.

4.2 Visits to industry

Visits to industry are very important, in order to get the student acquinted with the chemical industry. Many students were disillusioned with industry after their studies were completed. This could have been prevented if the student were in contact with the industry right from the beginning. At the present moment visits are a problem because of the limited time available. In the future this aspect will have to be improved.

4.3 Publications

To motivate the students one must encourage them to write short articles on popular relevant topics for publication. In South Africa there are journals like Archimedes for example in which articles of this nature can be published. We intend giving our students enough background information on a topic, and then to ask them to get supplementary information and to write a short article on the subject for publication.

In this way the student gets an introduction to the chemical literature. We hope that this approach will motivate them to study further in the natural sciences and perhaps become practising chemists.

5. Summary

Although the teaching of Organic Chemistry to the gifted is still in the infant stages, the results seem to be encouraging. If major problems like time availabvle etc. could be solved this teaching could contribute to the availability of more natural scientists to the industry.

Something to consider is the founding of a school just for the gifted. More time than under the present circumstances will be available, and more additional study material could be taught.

This may be something for the future.